NTSB National Transportation Safety Board

Office of Highway Safety

Tunnel Design, Inspections, and National Standards

Dan Walsh

Topics

- Design of the D Street portal ceiling
- Tunnel inspections
- National standards for tunnel finish designs

Project Oversight

Federal Highway Administration

MassHighway
Mass. Turnpike Authority

Design and Construction

Bechtel/Parsons Brinckerhoff (B/PB)

Gannett Fleming, Inc.

Conam Inspection, Inc. ↔ Modern Continental Construction, Inc.

Epoxy

Sika Corporation

Powers Fasteners, Inc.

Newman Renner Colony, Inc.

Design Loads

- Anchor designed for 2,600 pounds
- Finite element analysis
  - Model anchor loads
  - Determine structural redundancy
  - Examine different “hanger-out” scenarios

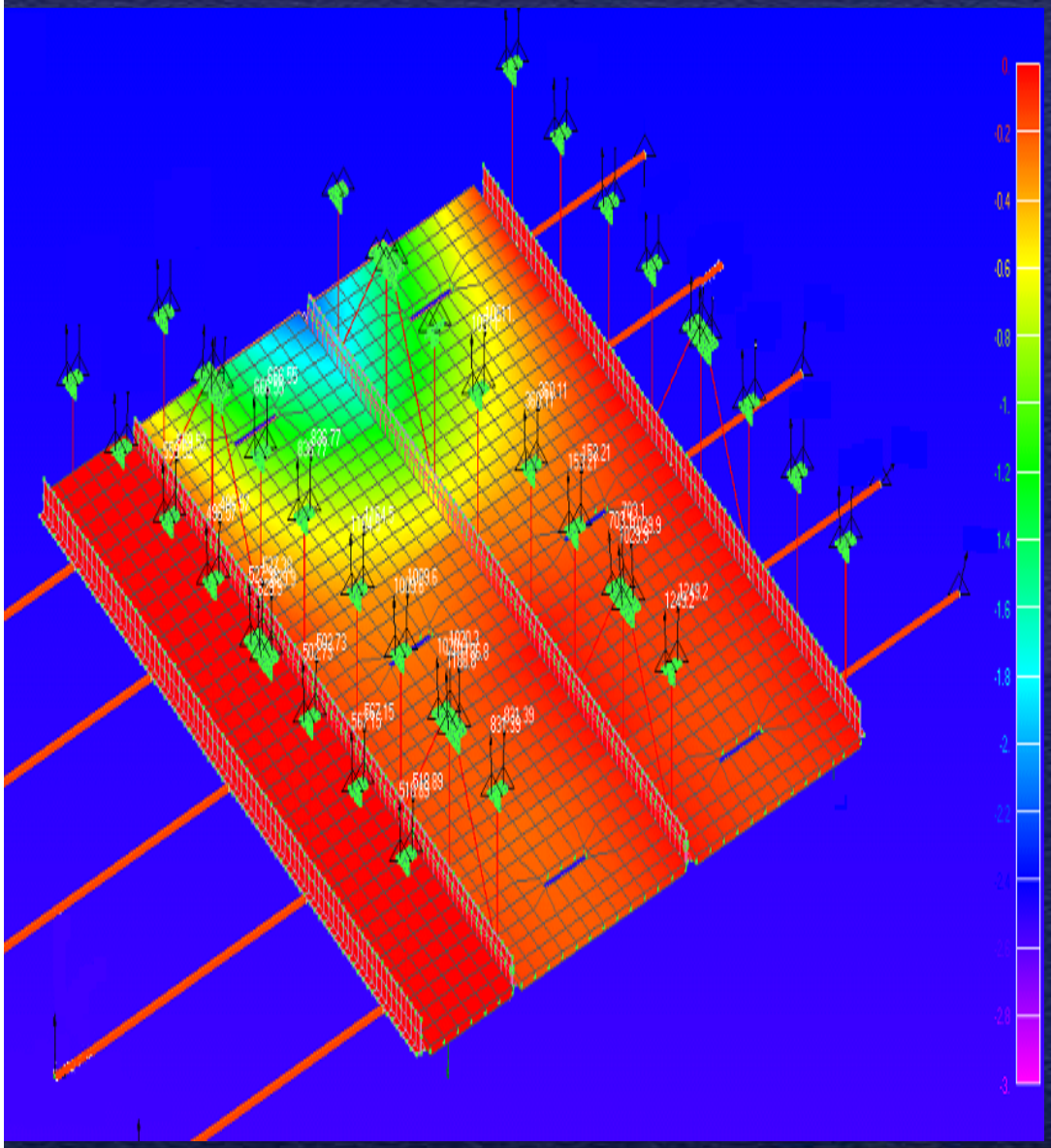
NTSB

Design Loads

- Powers Fasteners anchoring system
- Average expected load capacity of 25,400 pounds
- Safety factor of 4
- Allowable load of 6,350 pounds
- Anchor design load of 2,600 pounds

NTSB

Finite Element Analysis



- One hanger removed, loads remained below 6,350 pounds
- Two or more hangers removed, loads remained below 25,400 pounds

NTSB

Responsibility of Consultant

- Gannett Fleming
  - Develop detailed design
  - Review submittals and prepare responses
- Affixed engineer's professional seal
- Evaluation of each component of the ceiling system

NTSB

Anchor Specification

- Failed to account that adhesives creep
- Adhesive anchors in pure tension was an atypical application
- Adhesives have different properties

NTSB

Anchor Specification

- No specification regarding long-term properties
- No requirement for testing for long-term performance
- No consideration of service life
- No provision for periodic inspection

NTSB

Anchor Approval

- Opportunity to address creep in the approval process
- Contractor's proposed anchoring system
  - Draft version of ICBO Report ER-4514
  - Fast Set epoxy approved for short-term loads only
- Gannett Fleming authorized work to proceed

NTSB

Preaccident Anchor Failures

- Opportunities to determine poor long-term characteristics of the adhesive
- First opportunity in HOV tunnel (September 1999)
- Suspected improper anchor installation
- Powers evaluated the anchor installation (October 1999)

NTSB

Preaccident Anchor Failures

- Remove and replace all failed anchors
- Proof test to higher load of 6,350 pounds
- Higher load would not identify poor long-term load characteristics
- Anchor performance should have been monitored

NTSB

Preaccident Anchor Failures

- Additional opportunity in eastbound I-90 connector tunnel (late 2001)
- Remedy developed was ineffective
- Considered the continuing failures as isolated instances

NTSB

Preaccident Anchor Failures

- Problem attributed to installation, including overtorquing the nuts
- Tests showed overtorquing did not reduce load capacity
- Powers did not recommend to continue to monitor the anchor performance

NTSB

Summary

- B/PB and Modern Continental should have instituted a program to monitor anchor performance
- Powers response to the anchor displacements was deficient

NTSB

NTSB